

Summary of Science to Technology Breakout on Energetic Materials at the 2017 MaRIE Drivers Workshop

Paul Specht

Sandia National Laboratories, Albuquerque NM, 87185

Energetic Materials

Energetic materials (i.e. explosives, propellants, and pyrotechnics) have complex mesoscale features that influence their dynamic response. Direct measurement of the complex mechanical, thermal, and chemical response of energetic materials is critical for improving computational models and enabling predictive capabilities. Many of the physical phenomena of interest in energetic materials cover time and length scales spanning several orders of magnitude. Examples include chemical interactions in the reaction zone, the distribution and evolution of temperature fields, mesoscale deformation in heterogeneous systems, and phase transitions. This is particularly true for spontaneous phenomena, like thermal cook-off. The ability for MaRIE to capture multiple length scales and stochastic phenomena can significantly advance our understanding of energetic materials and yield more realistic, predictive models.

The first energetic materials experiments on MaRIE would focus on void collapse in single crystals of high explosive. This is a problem extensively investigated with atomistic computations for understanding “hot spot” formation and initiation. MaRIE could provide the first high resolution images of the complex wave and material interaction present during a void collapse for model validation. Such an experiment would require at least 30 images, spanning several microseconds, over a 150 micron domain with 1 micron resolution. The biggest challenge to its success, and the success of any energetic materials experiment at MaRIE, are the large standoffs necessary for many energetic materials studies. These large standoff distances make diagnostic access and alignment difficult.

To study all the phenomena of interest in energetic materials at MaRIE, a range of drivers and laboratory spaces is desired. This includes projectile launchers, laser drives, pulsed power drives, and explosive chambers. In addition, a set of universal requirements are necessary for energetic materials studies. The first is a 3 to 10 microsecond insertion delay for diagnostic timing on drivers with large timing jitter, such as projectile launchers. The second, is large (e.g. 100 meter) standoffs for small angle x-ray scattering (SAXS) measurements. Lastly, an imaging capability with up to 30 frames.

Each of the desired drivers at MaRIE has its own unique set of additional requirements for energetic materials studies.

Projectile Launchers

The projectile launchers at MaRIE must span an impact velocity range of 0.4 to 6.0 km/s. The projectile launchers at MaRIE need to be mobile such that they can be positioned relative to the beamlines. A successful model of such a system is the Dynamic Compression Sector at the Advanced Photon Source at Argonne National Laboratory. The target chambers on each projectile launcher must have a NEW limit of 10's of grams and coupling with Proton Radiography (pRad) for dual scale measurements.



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Laser Drive

Both short and long pulse lasers are desired at MaRIE for energetic materials studies. For the short pulse laser, a 10 joule output with advanced pulse shaping and pulse widths from a femtosecond to a nanosecond is desired. For the long pulse laser, a 1 kilojoule output with advanced pulse shaping, a square centimeter spot size, and up to a microsecond pulse width are desired. Each laser would need a cartridge system for automatic sample insertion and a high repetition rate.

Pulsed Power Drive

A 5 MA THOR class pulsed power machine with an NEW limit of 10 grams is desired at MaRIE.

Explosive Chambers

MaRIE should have explosive chambers that are rated for firing systems up to 50 kV and NEW limits of 1 kg.



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